

importance to this as a source of the materials in our deep deposits.

2. We have the dust of deserts, which is carried great distances by the winds, and which, falling upon the ocean, sinks to the bottom and adds to the depositions taking place. In the trade-wind regions of the North Atlantic we have a very red-coloured clay, in deep water, which is largely made up of dust from the Sahara. Such dust frequently falls in this region as what is called blood-rain.

3. We have the loose volcanic materials, which have been shown to be universally distributed as floating pumice, or as ashes carried by the wind.

This short review shows that the clay in shore deposits is chiefly derived from river and coast detritus. As we pass beyond about one hundred and fifty miles from the shores of a continent the character of the clayey matter changes. It loses its usual blue colour, and becomes reddish or brown, and particles of mica and rounded pieces of quartz give place to pumice, crystals of sanidin, augite, olivine, &c. All this goes, I think, to show that in deposits far from land the clay is chiefly derived from volcanic *débris*, though in the region of the North Atlantic trade-winds much of it may be derived from the feldspar in the dust of the Sahara.

The pumice which floats about on the surface of the sea must be continually weathering, and the clay which results and the crystals which it contains will fall to the bottom, mingling with the deposit which is in course of formation. In our purest globigerina ooze this clay and these crystals are present. If a few of the shells, say thirty foraminifera, are taken from such a deposit, and carefully washed, and then dissolved away with weak acid, a residue remains, which is red-brown or grey in colour, according to the region from which the ooze came. If the same number of shells be collected from the surface and dissolved away in the same manner, no perceptible residue is observed. The clayey matter would therefore seem to have infiltrated into the shells soon after they fell to the bottom.

I have already mentioned several instances of pumice-stones having been found on coral-reefs. Many more instances could be given. These stones, undergoing disintegration in these positions, add clay, crystals of augite, hornblende, magnetic iron ore, &c., to the limestones which the coral animals are building up.

I have found these crystals in the limestones and red earth of Bermuda, and in a specimen of the limestone from Jamaica.

This observation, it appears to me, points out that the red earth of Bermuda, Bahamas, Jamaica, and some other limestones, may originally have been largely derived from fragmental volcanic materials, which were carried to the limestone while yet in the course of formation. There are also small particles of the peroxide of manganese in the red earth of Bermuda.

(To be continued.)

## CHEMISTRY AND TELEGRAPHY<sup>1</sup>

DISCLAIMING at the outset any pretensions which could be advanced in his behalf for the honour conferred upon him, Prof. Abel assumed that his advancement to the position of president was intended more as a recognition of the special importance of chemical science in its application to telegraphy. Proceeding upon this assumption he made chemical science the basis of his address, and went on to show the principal directions in which it bears importantly upon the work of the telegraph engineer.

No stronger evidence of the value attaching to a combination of chemical with electrical research need be sought for than that which is to be found in the labours of the late Dr. Matthiessen. His investigations into the causes of the differences in the resistance of various kinds of commercial copper were followed by most important results.

The series of experiments so carefully conducted by him showed the influence which the principal metalloids and metals known to be naturally associated with copper exerted upon the conducting power of the pure metal, and he afterwards determined the conducting power of important varieties of commercial copper, and thus rendered it possible to assign to their real causes the enormous differences in the value of various kinds of commercial copper as conductors of electricity. For instance, amongst the many facts established by Matthiessen's experiments was the im-

portant one that by no combination of any other metal or alloy was it possible to increase the conducting power of pure copper, but that, on the contrary, a most prejudicial effect was exerted upon it by the presence of some of the non-metallic elements—notably oxygen and arsenic—which are almost invariably to be found as impurities in the copper of commerce. It was these non-metallic impurities he found rather than the presence of any of the other metals which chiefly impaired the conductivity of copper, although both iron and tin exercised a deleterious influence. Thus, fixing the conductivity of pure galvano-plastic copper at 100, the addition of merely traces of arsenic reduced it to 60; while an addition of 5 per cent. brought it as low as 6·5; the existence, again, of 1·3 per cent. of tin in pure copper reduced its conductivity to 50·4, and with only 0·48 per cent. of iron present the conductivity fell to 36.

Specially interesting were the experiments made by Matthiessen to ascertain the cause of the good effects which had long before his day been observed to be produced upon the working qualities of refined copper by the addition of minute quantities of lead. The existence of 0·25 per cent. of lead in copper renders it so rotten that it cannot be drawn into wire; the presence of even so minute a trace as 0·1 per cent. unfits it for wire-drawing. Some special action must therefore take place during the melting of copper which would serve to account for the toughening and softening effects obtained by the addition of a small quantity of lead. The fact that the copper when subjected afterwards to a most careful analysis shows nothing but the merest traces of lead, would indicate that during the process of melting, the lead combines with and removes from the copper some impurity which would otherwise materially affect its toughness and ductility. The well-known affinity of lead for oxygen, combined with the fact that the presence of oxygen in copper beyond some narrow limit was known to affect its quality prejudicially, afforded good reasons for supposing that this impurity could be nothing else than oxygen, and this view, which was further supported by the beneficial influence of lead when employed in casting operations with copper and gun metal, received the strongest confirmation of its correctness from Matthiessen's experiments. Thus, the addition of 0·1 per cent. of lead to a sample of copper (the two being fused together in a current of carbonic acid), raised its conductivity from 87·25 to 93, and the amount of lead remaining in the metal after that was too minute to be detected. So with tin, the alloying of 1·3 per cent. of which with copper reduced, as has been already stated, its conductivity to 50·4; yet on melting the sample fused in contact with air with 0·1 per cent. of tin raised its conductivity to 94·55.

It was these investigations of Matthiessen which indicated to the wire manufacturer whence he could obtain or how best fulfil the conditions for the purity of a quality of copper, which would meet the requirements of a conductor whose size might be laid down by the telegraph engineer, whilst his researches into the preparation of alloys brought the most valuable aid to the B.A. Committee of 1861, in their determination of the standards of electrical resistance.

But it is not only in facilitating the selection of suitable materials for *conductors*, as well as in raising their quality as such that chemical science has brought important aid to the telegraph engineer; it has been most usefully applied in the investigation and determination of the materials most suitable as the *dielectrics* of telegraph cables, and it is in this direction that telegraphy may look in the future for the most valuable results from the labours of the chemist. Dr. Miller's investigations (instituted at the desire of the Submarine Telegraph Committee) into the causes of the decay of gutta-percha and india-rubber, confirmed the results which Hoffman had already communicated in 1860 to the Chemical Society and which Mr. Spiller had obtained some years afterwards. But Miller examines more in detail than either of his predecessors has done, into the changes which these gums undergo, and firmly established the fact that the alterations in their structure, resulting in the gradual destruction of their insulating powers, was due entirely to atmospheric influence, accelerated by the exposure of the material to light. He further pointed out that intermittent exposure to moisture, especially if solar light has access, rapidly destroys gutta-percha, whilst if kept continually immersed in water it remains unchanged for an indefinite period. He also showed that commercial gutta-percha contained, previous to any special exposure to oxidising influences, as much as 15 per cent. of resinous matter and a considerable amount of water (2·5 per cent.) mechanically diffused through it. Considerable improvements had doubtless been made since that date in the mechanical processes for preparing gutta-percha, but these

<sup>1</sup> Abstract of Address at the opening meeting of the Society of Telegraph Engineers, January 24, by the President, Prof. Abel, F.R.S.

do not appear to have been attended with similar improvements in the quality of the material as indicated by its chemical composition, for the highest quality of sheet gutta-percha which Prof. Abel himself had been able to find contained 12.7 per cent. of resinous matter and 5 per cent. of water. Much greater pains are no doubt taken to consolidate the material and express the water from the gutta-percha coatings of wire than in the manufacture of sheet gutta-percha. Nevertheless, that a considerable amount of inclosed water still remains is evidenced by the fact that in two samples of covered wire, submitted by the same manufacturers as lately as September and November last, the one contained 1.86 per cent., and the latter 3.97 per cent. of water. Little doubt now remains that the processes of "mastication" (to which gutta-percha is subjected for the removal of certain impurities and the production of a mechanically homogeneous material) favours oxidation, so that the destruction of some of the most valuable qualities of gutta-percha as an insulator depend upon the degree of completeness to which the mechanical impurities have been removed. An examination of *old* gutta-percha seems to show that, provided the material has been reduced to a compact condition, oxidation due to exposure to the air and light proceeds but slowly.

Dr. Miller also points out that mastication promoted the oxidation of *india-rubber*, and further experience has established the similarity of the two gums in this respect. The application of vulcanising to *india-rubber* was hailed as a most important step in submarine telegraphy; but although many chemists have made this same process of vulcanising a subject for study and investigation, it remains imperfectly understood even to the present day. The wire manufacturer had no difficulty in meeting the most important objection urged against the application of the vulcanising process (*viz.*, the injury done to the conductor by the chemical action of the sulphur in the dielectric upon it) by availing himself of the fact that tin would not be equally affected, and so protecting the copper by the simple process of tinning. Still the tendency to an alteration, either in the chemical or mechanical structure of vulcanised *india-rubber*, exhibited by it when kept submerged in water, has developed serious elements of uncertainty in cables prepared by the vulcanising processes. Prof. Abel then proceeded to give some interesting illustrations drawn from his own personal experience of the uncertainty of our existing knowledge regarding the chemical and other conditions to be fulfilled in the application of vulcanising processes to the preparation of telegraph cables.

A number of half-mile lengths, for instance, of vulcanised telegraph cable—some for field service, others for firing broadsides on board ship—were found, after a period varying from eighteen months to three years, to have undergone considerable deterioration; the dielectric in some instances had become so porous that even the variations in the hygroscopic condition of the atmosphere on board ship, where the wires were placed between decks, caused decided differences in the results obtained with a particular battery power; and this alteration was not distributed uniformly over a length, the porosity in some instances extending along a few feet only, the adjacent portions being in very good condition; an inspection of a large quantity of the same sort of cable which had remained untouched in store showed precisely similar results.

The uncertainty attaching to this is still further illustrated by the fact that in armoured cables with multiple cores of this description some of the cores remain comparatively good, whilst the insulation of others had fallen off to a very great extent.

Scarcely less conflicting is the experience gained with cables prepared according to Hooper's system. This system consists in maintaining the inner portion of the *india-rubber* surrounding the conductor in an unvulcanised condition by means of a "separator," which contains a preparation of a metal possessing the power of arresting the passage of the sulphur beyond it during and subsequent to the application of the vulcanising process.

The deterioration due to the alteration of the *india-rubber* being caused by oxidation, the question naturally arises as to how the oxygen finds access to it? It must evidently find access to the interior of the dielectric *through the substance of the cable*—a view which is more than confirmed by the researches of Graham. That eminent chemist showed that solid *india-rubber* absorbed oxygen to an extent which showed the gas to be twice as soluble in it as in water at the ordinary temperature, and the comparatively greater priority of vulcanised *india-rubber* would favour this absorption. The oxidation of unvulcanised *india-rubber* being once established, the tendency to the absorption of oxygen by the external vulcanised *india-rubber*, and to its passage through

the latter, must be promoted by the increased tendency to chemical change of and continual assimilation of oxygen by the inner portion, which thus acts like the vacuum by which Graham caused air very rich in oxygen to filter through a stout vulcanised *india-rubber* tube.

The efforts made from time to time to improve the insulation of cables, served until lately to clear the ground for future experiments, but of late important success seems to have been achieved in a direction where different experimenters (including Prof. Abel himself) had failed—that direction is towards paraffin, "a substance which during the last thirty years had passed from the obscure position of a chemical curiosity to the foremost rank amongst important chemical products." In 1875 Mr. Field, F.R.S., working in conjunction with Mr. Talling, the mineralogist, produced by means of a solvent, or by masticating the substances together, a black ozokerit-product with *india-rubber*, which appeared quite free from the brittleness which Matthiessen, who also had been at work here, failed to get rid of. This preparation in point of insulation and inductive capacity compares very favourably with *india-rubber* and gutta-percha, and would seem likely to prove very valuable for telegraphic purposes in the future.

Prof. Abel could only allude to the importance of chemical science in the proper management of batteries, a subject which, after the valuable paper read before the Society by Mr. Sive-wright, "On Batteries and their Employment in Telegraphy," and the instructive discussions which it elicited, needed only to be named. Amongst other matters of importance where the telegraph engineer might derive great benefit from the fruits of applied chemistry, were the decay and preservation of telegraph poles, the preservation of fibrous materials used in constructing submarine cables, the production of points and the protection of cables against the deposition of vegetable or animal growth.

Prof. Abel then concluded his address by a final illustration of the manner in which the practical electrician may unexpectedly be brought face to face with problems which can be solved by a knowledge of chemistry and by that alone. Lieut.-Col. Stotherd, R.E., having pointed out certain defects in the permanency and difficulties connected with the testing of Abel's "phosphide" fuse, he (Prof. Abel) constructed another form of high tension fuse specially designed for submarine mining. The poles of this new fuse were 0.05 of an inch apart, in an insulating column consisting of Portland cement with sufficient sulphur to allow of its being melted and cast in a mould. Fuses manufactured in this way were supplied to different military stations, and after a time it was found that the average resistance of the fuses being 15,000 ohms, that of many of them had fallen as low as 300 or 400 ohms, and one or two had gone down even below 50 ohms. The cause of this at first sight inexplicable change in the stability of the fuse was traced by Mr. E. O. Brown to the existence in many of the cement pillars of very minute hair-line cracks or fissures extending sometimes right across the space between the inclosed small copper wires. The sulphur in the cement and the copper wire in presence of the air which had penetrated with the ever-concomitant moisture had set up a galvanic action which had formed one or more complete bridges, thereby short-circuiting the copper poles. Chemical knowledge, which unravelled this mystery at once, provided the remedy; platinum, upon which sulphur and air were powerless, replaced the copper, and the permanence of the fuse was secured.

A hearty vote of thanks to Prof. Abel was carried by acclamation, and it was decided that the address should be printed and circulated amongst the members.

#### SCHOLARSHIPS AND EXHIBITIONS FOR NATURAL SCIENCE AT CAMBRIDGE, 1877

THE following is a list of the Scholarships and Exhibitions for proficiency in Natural Science to be offered at the several Colleges and for Non-Collegiate Students in Cambridge during the present year:—

*Trinity College.*—One or more Foundation Scholarships of 100*l.*, and one Exhibition of 50*l.* The examination for these will commence in the first week of April.

*St. John's College.*—One of the value of 50*l.* per annum. There is a separate examination in Natural Science at the time of the annual College examination at the end of the academical year, in May; and Exhibitions and Foundation Scholarships ranging in value up to 100*l.* will be awarded to students who